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EXTENT AND FREQUENCY OF INUNDATION ON THE PERKIOMEN CREEK FLOOD PLAIN FROM GREEN LANE RESERVOIR TO THE SCHUYLKILL RIVER (NEAR OAKS, PENNSYLVANIA)

By William F. Busch

Prepared in cooperation with
DELAWARE RIVER BASIN COMMISSION

Harrisburg, Pennsylvania
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Open-file report

PREFACE

This is the fourth report on the extent and frequency of inundation prepared for the Delaware River Basin Commission. The first of these reports covered floods on the Delaware River in the vicinity of Easton, Pennsylvania and Phillipsburg, New Jersey. The second covered a reach of the Schuylkill River from Conshohocken to Philadelphia. The third was for the Delaware River in the vicinity of Belvidere, New Jersey. The first and third reports were written by George M. Farlekas of the Trenton district, and the second was written by Arthur T. Alter of the Harrisburg district. Specific information as to the areal extent and contents of these studies can be obtained from the Delaware River Basin Commission, P.O. Box 360, Trenton, New Jersey.

This flood inundation study is part of an investigative program financed through a cooperative agreement between the U.S. Geological Survey and the Delaware River Basin Commission. The report was prepared under the direction of Norman H. Beamer, District, Chief, U.S. Geological Survey, Harrisburg, Pennsylvania.

The streamflow data for Perkiomen Creek at Graterford were collected by the Pennsylvania Department of Forests and Waters from 1914 to 1931. Since 1931 the data have been collected under a cooperative agreement between the U.S. Geological Survey and the Department of Forests and Waters. Data on high-water marks and areas inundated in past periods of flooding have been obtained from many local residents of Montgomery County. The Reading Company cooperated by allowing survey crews to work on their right-of-way. The author is grateful to Mr. John W. Buchanan for surveys, Mr. Lewis C. Shaw for illustrations and to Mrs. Joan C. King for typing.

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INTRODUCTION

Purpose and Scope

Knowledge of the frequency and extent of flooding is an important requirement for the design of all works of man bordering on streams or encroaching on flood plains. The proper design of bridges, culverts, dams, highways, levees, reservoirs, sewage disposal systems, waterworks, and all other structures located on the flood plains of streams requires careful consideration of flood hazards. When loss of life is not a factor, it is generally not economically sound to design all structures for the maximum flood that may occur. Economics will dictate the choice of a design flood frequency.

This report presents information relative to the extent, depth, and frequency of floods on Perkiomen Creek from Green Lane Reservoir to the mouth. This is a reach of 20.4 miles. All river distances used in this report are river miles measured upstream from the mouth and were supplied by the Delaware River Basin Commission.

By use of relations presented in this report the depth, extent, and frequency of flooding can be estimated for any site along the reach of the Perkiomen Creek under study. Flood data and the evaluation of the data are presented so that local and regional agencies, organizations, and individuals may have a technical basis for making decisions on the use of flood-prone areas. The Delaware River Basin Commission and the U.S. Geological Survey regard this program of flood-plain inundation studies as a positive step toward flood-damage prevention. Flood-plain inundation studies, when followed by appropriate land-use regulations, are a valuable and economical supplement to physical works for flood control. Both physical works and flood-plain regulations are included in the Comprehensive Plan for development of the Delaware River basin, of which the Perkiomen Creek is a part.

Recommendations for land use, or suggestions for limitations of land use, are not made herein. Other reports on recommended general use and regulation of land in flood-prone areas are available (Dola, 1961; White, 1961; American Society of Civil Engineers Task Force on Flood Plain Regulations, 1962; and Goddard, 1963). The primary responsibility for planning for optimum land use in the flood plain and the implementation of flood-plain zoning or other regulations to achieve such optimum use rest with the state, regional, county, and local interests. Appropriate municipal, county, and state agencies can use this report as a basic reference in the development of land use plans for the Perkiomen Creek flood plain. The preparation of this report was undertaken after consultation with representatives of the Water Resources Association of the Delaware River Basin and the Montgomery County, Pennsylvania, Planning Commission and after both had demonstrated the need for flood-plain information and willingness to consider flood-plain regulations.

Description of the Area

The area covered by this report consists of the Perkiomen Creek and its flood plain from the mouth to Green Lane Reservoir, a distance of 20.4 river miles, as shown on plate 1. Perkiomen Creek is a tributary to the Schuylkill River. The stream rises in Berks County and flows southeastward into Montgomery County. The reach covered in this report is wholly within Montgomery County. Flooding on tributaries is not covered in this report except for short distances above their mouths where they are affected by backwater from Perkiomen Creek. The major tributaries are Macoby, Deep, Unami, Swamp, East Branch, and Skippack Creek. The drainage area of Perkiomen Creek at the confluence with the Schuylkill River is 362 square miles.

There are two major dams below Green Lane Reservoir. These are Judge Knight at mile 19.2 and Wetherills Dam at mile 0.9 with heights of approximately 14 and 6 feet, respectively. There are also about 10 other dams in various stages of repair or disrepair. Sixteen highway and five railroad bridges cross the stream within the reach.

The Flood Plain

The channel of Perkiomen Creek in the reach under study runs through broken and hilly country within the Piedmont Plateau. Although it is sinuous in places, it has some rather long, nearly straight reaches. The valley width is irregular, varying from broad rolling agricultural and industrial land to narrow stretches flanked by steep banks. The average fall is about eight feet per mile.

Low agricultural areas are frequently flooded. Higher urbanized areas are occasionally flooded. During periods of major floods, many homes and commercial buildings have been damaged or totally destroyed. Some idea of the extent of flooding may be obtained from the cover picture and from the photographs included in this report, figures 1 and 2.

The most recently published flood-damage statistics compiled by the U.S. Army Corps of Engineers is for the August 19, 1955 flood, which reached a stage of 14.08 feet at the gage at Graterford. Damages at the level of development present in 1955 totaled $40,200 (1955 dollars) (HD 522, 87th Cong. 2nd Sess.).

METHOD OF ANALYSIS

Data Available

Gage Records

Streamflow data have been collected on Perkiomen Creek at Graterford since June 1914. The drainage area at this point is 279 square miles. Datum of gage is 112.66 feet above mean sea level, datum of 1929. The annual maximum gage heights and discharges are listed in table 1. Figure 3 depicts the gage heights in bar-graph form.

A record of daily discharges was kept from 1885 to 1913 at a site near Frederick that had a drainage area of 152 square miles. No records of momentary peaks for this gaging station are available; so, it is of little value for flood-frequency studies.

Maps

For use in this report, plate 1 was compiled and enlarged to a scale of 1:16,000 from the following $7\frac{1}{2}$ minute U.S.G.S. quadrangle sheets: Perkiomenville (1960), Collegeville (1951), and Valley Forge (1952). The Perkiomenville sheet has a 20-foot contour interval while the other two sheets have a 10-foot contour interval. In addition to this map (plate 1) which covers the entire length of the area studied, five enlarged maps at the scale of 1:4800 (1'' = 400') have been prepared for the entire length of the river under study. These expanded maps contain the same information (i.e. the 50-year and 2.5-year flood-frequency inundation area) and have been prepared to improve map legibility. Parts of these expanded maps are published in this report, plates 2 and 3. The entire set (five sheets) of the 1:4800 scale maps are available upon request (and at cost) in the offices of the Montgomery County Planning Commission, Court House, Norristown, Pennsylvania. One complete set of these enlarged maps is also on file at the Montgomery County Planning Commission offices and at each of the following agencies:

Delaware River Basin Commission, 25 Scotch Road,
P.O. Box 360, Trenton, New Jersey 08603

United States Geological Survey, P.O. Box 1107,
Harrisburg, Pennsylvania 17108

The Perkiomen Valley Watershed Association, P.O.
Box 55, Schwenksville, Pennsylvania 19473

Field Investigation

Field investigation in the fall of 1966 and spring of 1967 yielded information on maximum and minimum water-surface elevations and extent of inundation.

Investigations indicate that the flood of October 4, 1869, is the greatest known. This information was gathered from long-time residents and from newspaper articles published in the Norristown Times Herald and the Pottstown Mercury. The high-water marks for this flood are recorded on a wall in the Perkiomen Bridge Hotel in Collegeville. Accurate data on other floods is very scarce. Most of the people questioned were unsure as to the exact date when a high-water mark was reached.

The flood of July 9, 1935 (17.92 feet) was the greatest since the flood of 1869. Other major floods recorded on the gage at Graterford are listed below, in order of magnitude:

August 23, 1933 (16.81 feet); June 2, 1946 (16.17 feet); August 9, 1942 (15.81 feet); November 25, 1950 (14.79 feet). Gage heights are adjusted figures (see next section).

Flood-crest elevations that have been determined at various points on Perkiomen Creek are tabulated in table 2.

Levels were run in the spring of 1967 and elevations of high-water marks, profiles and cross sections were tied to mean sea level, datum of 1929. This vertical control was maintained by a line of levels tied to the bench marks listed in table 3.

Gage heights for flood peak discharges were computed from the current stage-discharge relation for station on Perkiomen Creek at Graterford. The recurrence intervals for these gage heights were then computed and used to define a stage-frequency curve. This curve reflects the frequency relationship for present channel conditions with respect to an annual series. The annual series relation was converted into partial duration series relation and is shown on figure 4. Adjusted gage heights were also used to plot the five highest floods that have occurred during the period of operation of the gaging station (1915-67) and to plot four lesser floods having shorter recurrence intervals. (See figure 4.) Actual gage heights were used on figure 3 and on table 1.

As applied to flood events, recurrence interval is the average interval of time within which a given flood height will be equaled or exceeded once. The recurrence interval does not imply periodicity. For floods having recurrence intervals greater than 10 years, the recurrence interval is virtually inversely related to the chance of a given flood discharge being equaled or exceeded in any one year. Thus, the 25-year flood has a four percent (1 in 25) chance of being equaled or exceeded in any one year. At Graterford, for example, a flood that reaches an elevation of 130.5 feet above sea level is said to have a 50-year recurrence interval. (See figure 4.) A 130.5-foot flood stage could be equaled or exceeded tomorrow, again next week, and again next month, but over a long period of time the interval between occurrence of a flood of this magnitude or greater will average 50 years.

The relationship between recurrence interval and gage height for Perkiomen Creek at Graterford is tabulated below. Gage heights and elevations are adjusted as explained on the preceeding page.

Historical Flood		Recurrence Interval
Gage Height (feet)	Elevation above mean sea level (feet)	(years)
17.9	130.5	50
16.8	129.5	25
16.2	128.8	20
15.8	128.5	13
14.8	127.4	8
14.3	127.0	7
13.7	126.4	5
11.9	124.6	2.5
11.1	123.8	1.8

The U.S. Geological Survey has published numerous Water-Supply Papers on the subject of floods. Two of the most beneficial for anyone interested in flood frequencies and flood inundation are Dalrymple (1960) and Wiitala, Jetter, and Sommerville (1961).

Modification of Flood Elevations Due to Major Control Structures

Neither the Green Lane Reservoir not the proposed Evansburg Dam on Skippack Creek can be relied upon to affect flood levels to any measurable degree, because they are not intended to be flood-control structures. The effect of having excess capacity available in the reservoir at the time of an intense storm is virtually impossible to measure, as there are an infinite number of possible combination of conditions. Therefore, the only realistic conclusion that can be drawn about these two major structures is that they may very well prove to have no effect on flood elevation, and the downstream communities should not be misled or "lulled" into a false sense of security.

Flood Profiles

The profiles of floods along Perkiomen Creek (figure 5) are based on high-water marks and other information provided by local residents. The profile for the flood of July 9, 1935, which was the highest since 1869, was well defined over most of the reach. There were also, many high-water marks for the flood of August 23, 24, 1933. As there were not many high-water marks for the flood of August 9, 1942, profile is available for it only from mile 9.9 to 12.4. The flood of March 7, 1967, occurred during the study period; so, it was fully defined by a survey made while the flood marks were still visible on the ground.

Figure 5 also shows elevations for the base-flow water surface as it existed during the period April 24 to May 2, 1967.

USE OF FREQUENCY AND PROFILE RELATIONS

This report can be used to reveal areas that would be flooded at specific frequencies and to compute the depth of flooding.

For example, a flood at an elevation of 130.92 feet at the Graterford gage (equal to the July 9, 1935 flood) is approximately a 50-year flood; that is twenty floods equal to or exceeding 130.92 feet can be expected in 1,000 years, on the average.

The irregular distribution of floods on the Perkiomen Creek is illustrated by figure 3.

Areal Extent of Flooding

The approximate areas inundated during the annual flood peaks of July 9, 1935, and March 7, 1967, are shown on plate 1. Inundated areas shown on tributaries are those that would be flooded by backwater from Perkiomen Creek only, but even more severe flooding could result from heavy local runoff.

The areal extent of flooding for any frequency of flood at any specific location along Perkiomen Creek can be found in the following manner:

1. Determine the elevation of the flood having the desired frequency at Graterford from flood-frequency curve of figure 4.
2. Determine the relative position of the selected flood with respect to known floods at Graterford, which are plotted on figure 5. For example, a 30-year flood would have an elevation of 129.6 feet on the Graterford frequency curve. The 50-year flood has an elevation of 130.5 feet, and the 25-year flood has an elevation of 129.3 feet. Then $\begin{array}{r}130.5\\ \underline{129.3}\\ 1.2\end{array}$ and $\begin{array}{r}129.6\\ \underline{129.3}\\ .3\end{array}$. Therefore, our 30-year flood should plot $\frac{3}{12}$ of the distance up from the 25-year flood to the 50-year flood on the profile figure 5.
3. Determine the river mileage at the selected location from plate 1 and locate the flood elevation found in 2, above, at this mileage on the profile figure 5.
4. Locate the point where the computed water-surface elevation intercepts the ground surface. For the most accurate results this should be done by differential leveling. If it is done on a topographic map the error is apt to be plus or minus half the contour interval.

Depth of Flooding

The depth of flooding can be estimated by subtracting the ground elevation at any specific point from the water-surface elevation obtained from the profile in the manner described above.

CROSS SECTIONS

Figures 6 to 9 show typical cross sections along the reach of Perkiomen Creek covered by this report. These cross sections are presented to show the different conditions that exist on the creek.

The characteristics of these sections vary greatly, the stream may be wide or narrow, deep or shallow, the banks may be steep with no flood plain or with wide gradually sloping flood plains. Many sections contain brush covered islands, others have bars that are above water only at low stages. All combinations of the above characteristics can be found in the reach under study. Characteristics of cross sections taken just a short distance upstream or downstream from each other may show large variations. The scouring and filling action of the stream, especially during periods of high flow, may cause extensive changes in the cross sections.

LIMITATIONS OF DATA

When we use streamflow records of hydrologic events to estimate the possibility of similar events occuring in the future, we should understand fully the limits of this methodology. Flood records have been kept for only a relatively short period of time and we have no assurance that meteorological conditions will not change in the future. Modern man has made great changes in the topography and the vegetation of the country. These changes may have large effects on the runoff characteristics of a basin or on the carrying capacity of a stream.

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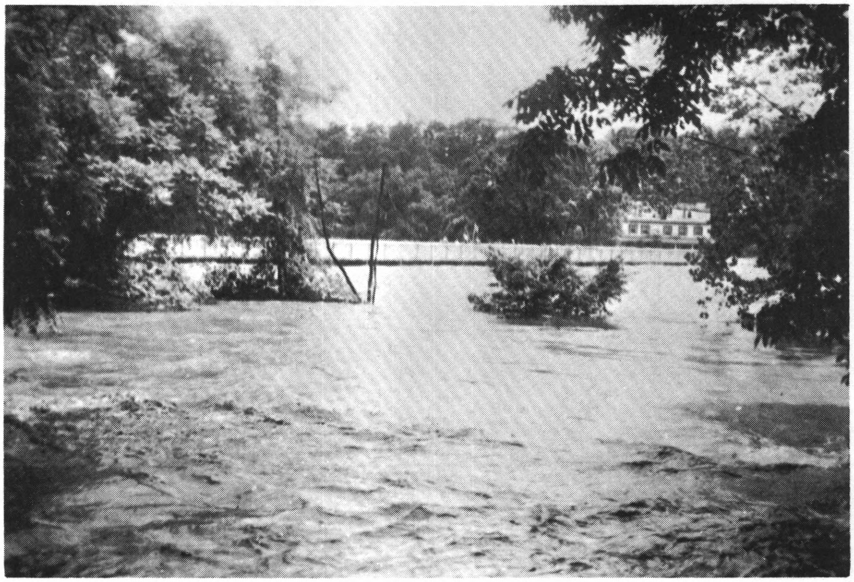

Figure 1.--Perkiomen Creek at Arcola, Pa. during flood of July 9, 1935.

Figure 2.--Same site thirty-two years later.

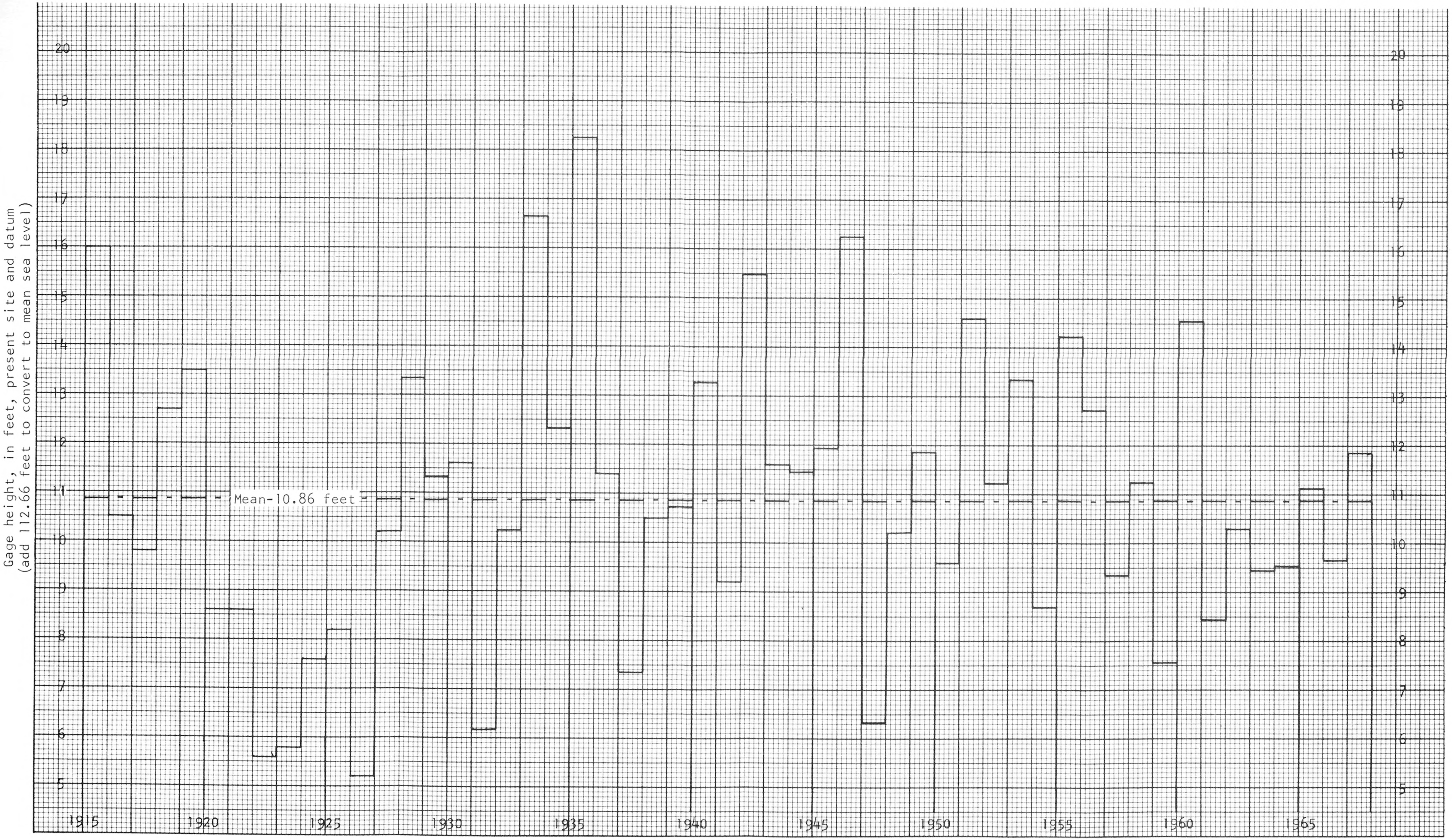

Figure 3.--Gage heights of annual maximum flood peaks on Perkiomen Creek at Graterford, Pa. 1915-67

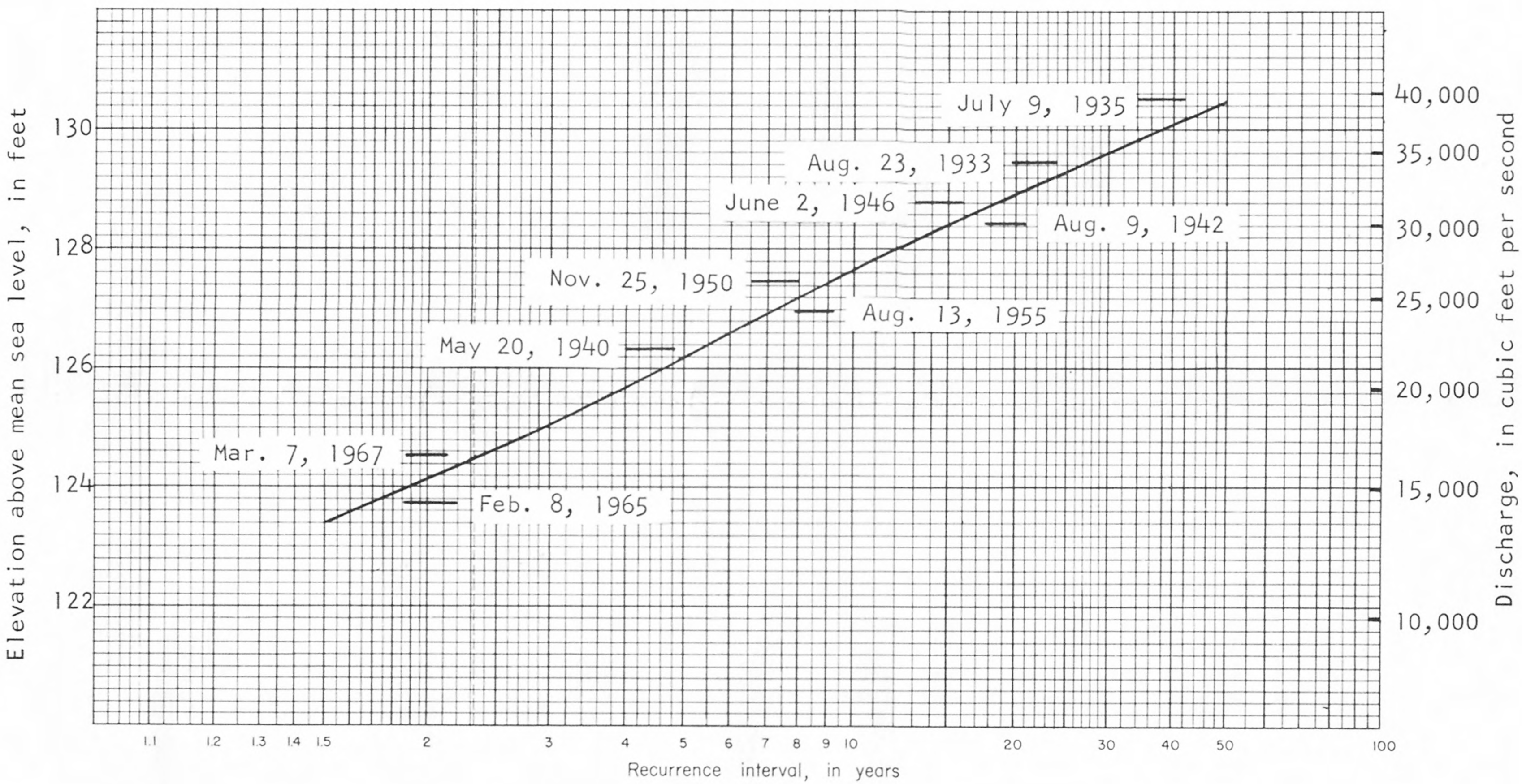

Figure 4.--Frequency of floods on Perkiomen Creek at Graterford, Pa.

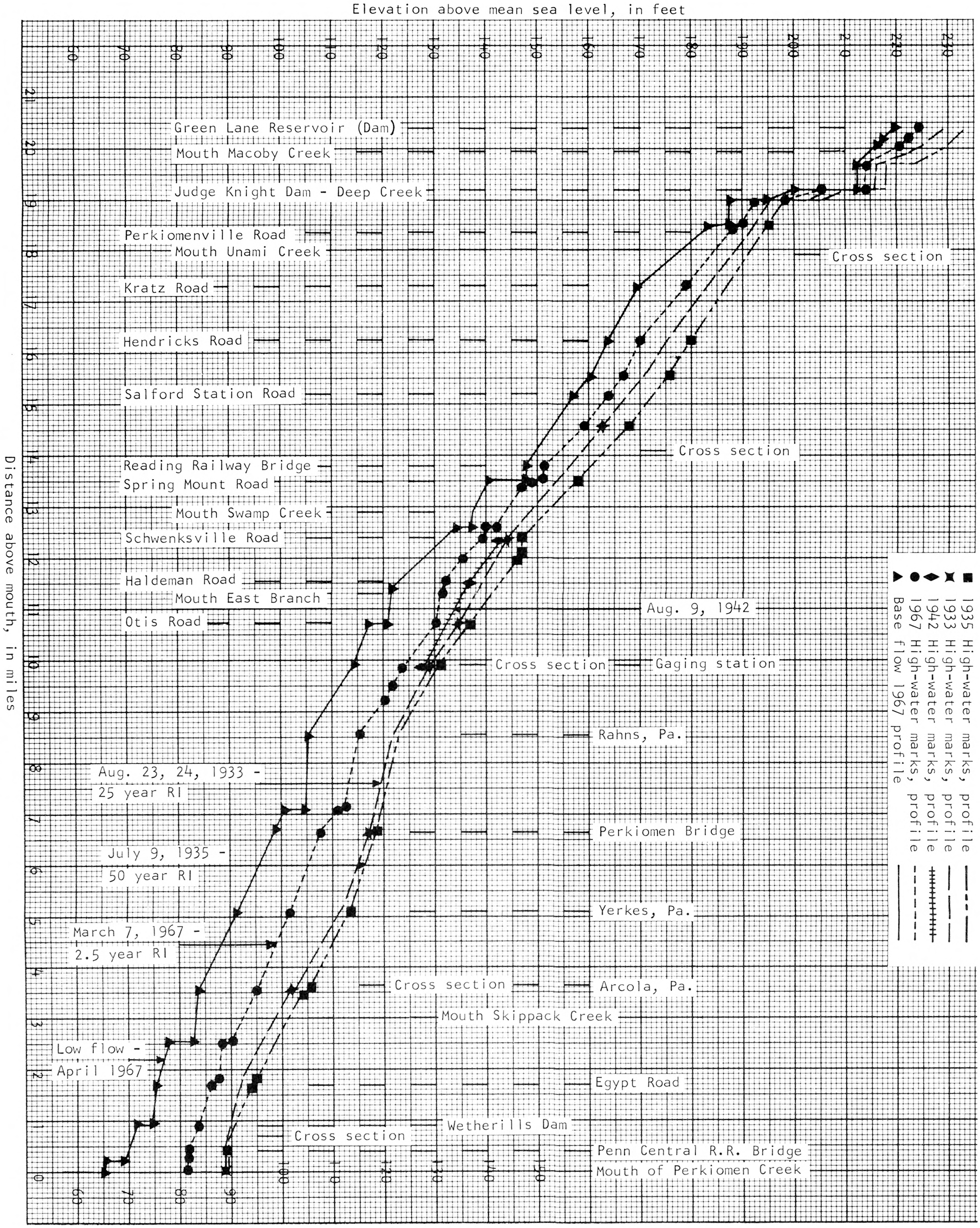

Figure 5.--Flood profiles on Perkiomen Creek

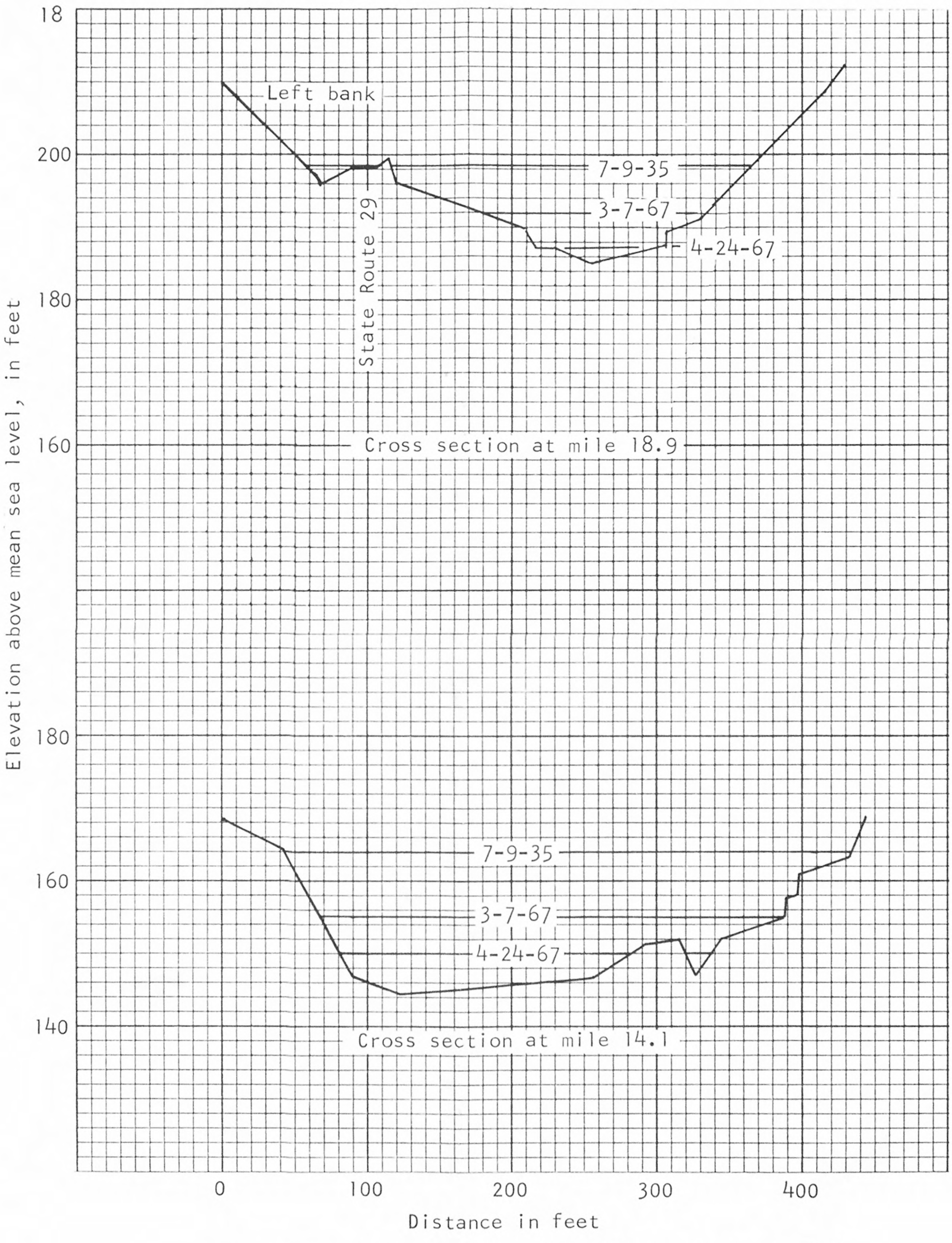

Figure 6.--Cross sections of Perkiomen Creek at 18.9 and 14.1 miles upstream from mouth

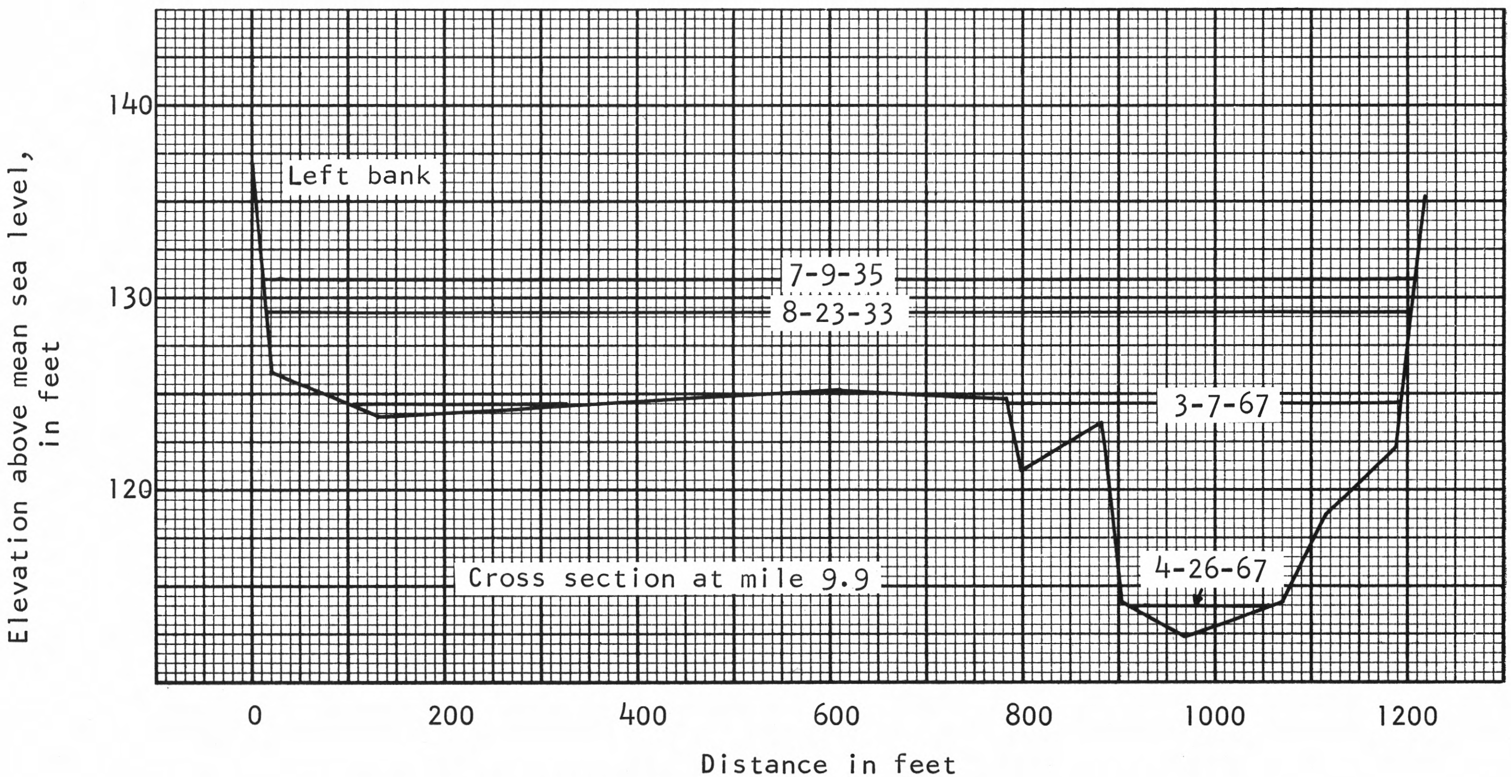

Figure 7.--Cross section of Perkiomen Creek at 9.9 mile upstream from mouth

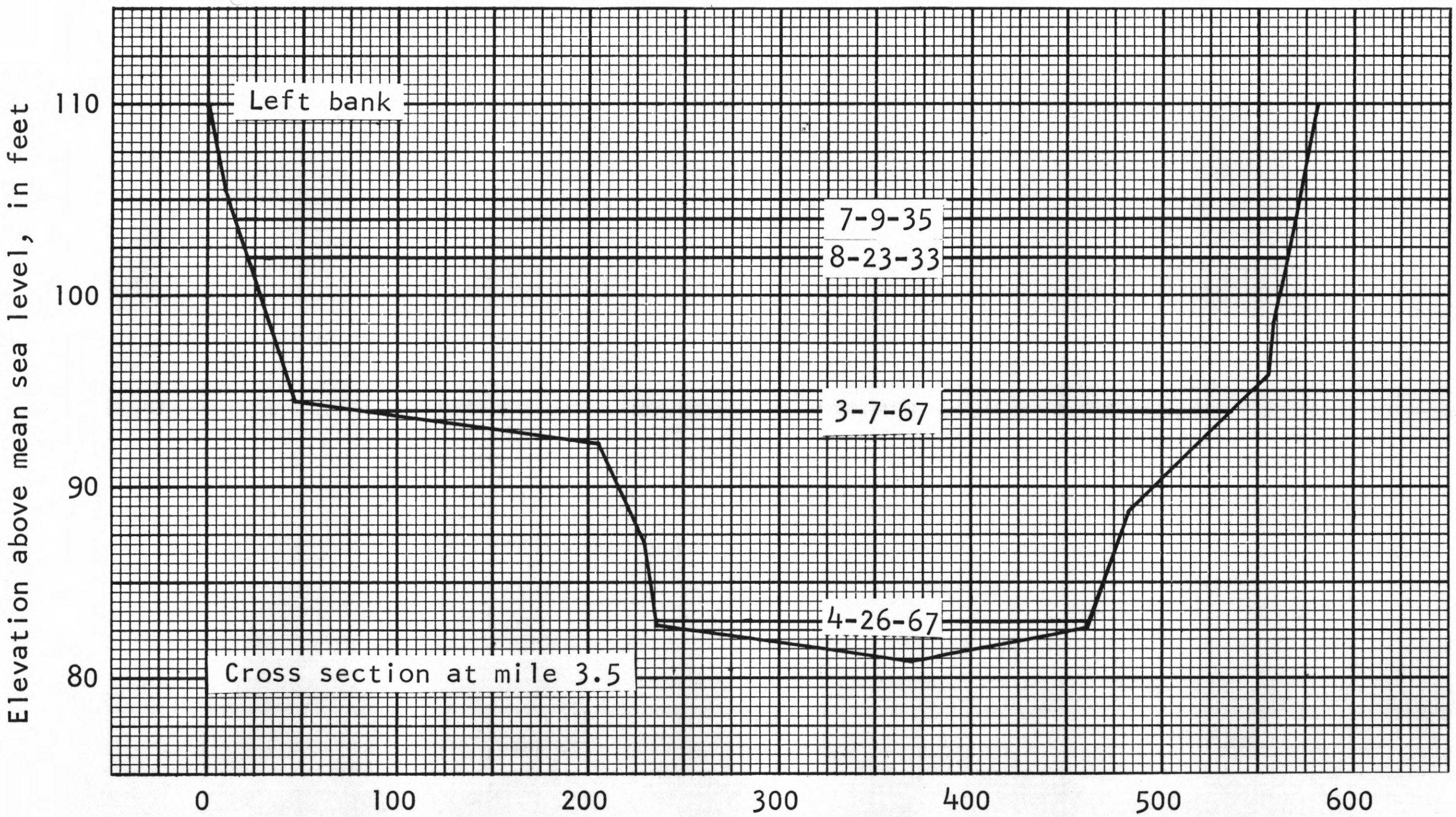

Figure 8.--Cross section of Perkiomen Creek at mile 3.5

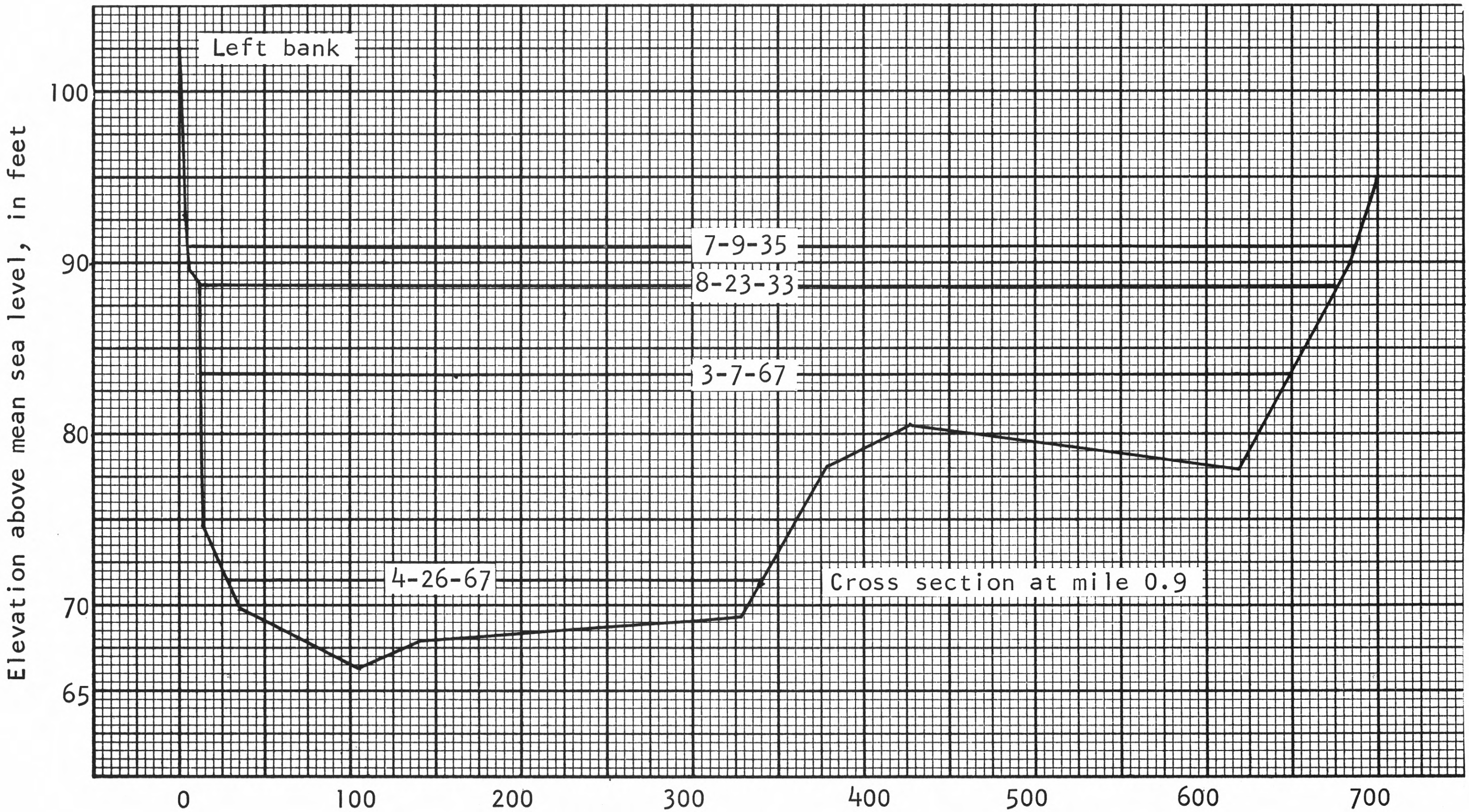

Figure 9.--Cross section of Perkiomen Creek at mile 0.9

Table 1.--Maximum annual floods, Perkiomen Creek at Graterford, Pa. 1915-67

(Drainage area 279 square miles. Datum of gage is 112.66 feet above mean sea level, datum of 1929.)

Water year	Date	Gage height (feet)	Discharge (cfs)	Water year	Date	Gage height (feet)	Discharge (cfs)
1915	Aug. 4, 1915	14.5	24,900	1942	Aug. 9, 1942	15.50	30,200
1916	Dec. 18, 1915	9.3	10,200	1943	June 18, 1943	11.62	17,000
1917	Mar. 12, 1917	8.6	8,814	1944	Nov. 9, 1943	11.43	16,400
1918	Feb. 15, 1918	11.5	15,600	1945	Jan. 1, 1945	11.94	17,900
1919	July 21, 1919	12.1	17,400	1946	June 2, 1946	16.23	31,700
1920	Nov. 13, 1919	7.3	6,720	1947	May 5, 1947	6.35	5,230
1921	Feb. 28, 1921	7.3	6,700	1948	May 13, 1948	10.19	12,200
1922	Mar. 20, 1922	5.6	4,120	1949	Dec. 30, 1948	11.85	17,800
1923	Mar. 16, 1923	5.8	4,420	1950	Mar. 23, 1950	9.61	10,900
1924	Apr. 6, 1924	7.6	7,200	1951	Nov. 25, 1950	14.60	26,100
1925	July 26, 1925	8.2	8,220	1952	Apr. 28, 1952	11.21	16,100
1926	Mar. 7, 1926	5.2	3,530	1953	Nov. 22, 1952	13.36	22,400
1927	Nov. 16, 1926	10.2	13,000	1954	Dec. 14, 1953	8.68	9,740
1928	July 14, 1928	13.36	21,200	1955	Aug. 13, 1955	14.26	24,200
1929	Feb. 26, 1929	11.22	14,700	1956	Oct. 15, 1955	12.72	19,100
1930	Oct. 2, 1929	11.62	15,800	1957	Apr. 5, 1957	9.35	10,500
1931	July 14, 1931	6.16	5,020	1958	Feb. 28, 1958	11.23	14,700
1932	Mar. 28, 1932	10.27	12,400	1959	Mar. 6, 1959	7.52	7,040
1933	Aug. 23, 1933	16.65	34,600	1960	Sept. 12, 1960	14.55	25,400
1934	Sept. 30, 1934	12.34	19,100	1961	Feb. 26, 1961	8.44	8,580
1935	July 9, 1935	18.26	39,900	1962	Mar. 12, 1962	10.31	12,400
1936	Jan. 3, 1936	11.40	16,400	1963	Mar. 6, 1963	9.44	10,500
1937	Feb. 22, 1937	7.38	6,770	1964	Jan. 9, 1964	9.51	10,700
1938	Sept. 21, 1938	10.50	14,000	1965	Feb. 8, 1965	11.11	14,500
1939	Feb. 3, 1939	10.75	14,800	1966	Feb. 13, 1966	9.66	11,000
1940	May 20, 1940	13.28	22,100	1967	Mar. 7, 1967	11.86	16,600
1941	Dec. 17, 1940	9.21	10,100				

Table 2.--Flood-crest elevations on Perkiomen Creek

Miles above mouth	Location	Elevation above mean sea level, in feet					
		Aug. 23, 1933	July 9, 1935	Aug. 9, 1942	June 2, 1946	Mar. 7, 1967	Low water Apr. 24, May 2, 1967
20.4	Green Lane Reservoir - crest of dam...					287.6	286.0
20.39	Green Lane Reservoir - base of dam....					225.0	219.8
20.08	Reading Railway Bridge................					221.4	216.4
19.99	Kleinback Lumber Co. on Macoby Creek..	232.2	233.5				
19.9	Jake Kulp's Service Station...........		234.7				
19.7	Reading Railway Bridge................					214.8	212.6
19.2	Judge Knight Dam......................					u214.3 d205.8	u212.8 d200.6
19.0	Dam...................................					u198.5 d192.7	u195.3 d187.8
18.5	Dam and Mill..........................		195.3			u190.2 d188.2	u187.8 d183.4
17.3	Kratz Road............................					179.2	169.8
16.25	Hendricks Road........................		180.3			170.3	164.0
15.6	House.................................		176.1			167.3	160.8
15.21	Salford Station Road..................	168.9				164.3	157.3

Table 2.--Flood-crest elevations on Perkiomen Creek--Continued

Miles above mouth	Location	Elevation above mean sea level, in feet					
		Aug. 23, 1933	July 9, 1935	Aug. 9, 1942	June 2, 1946	Mar. 7, 1967	Low water Apr. 24, May 2, 1967
14.6	Stone Wall - Mr. Pool's farm..........	163.8	168.2			159.6	
13.8	Reading Railway Bridge................					151.6	
13.55	Dam...................................					u151.2 d149.0	u148.2 d141.0
13.50	Spring Mount Road.....................		158.3			u149.0 d147.9	
12.9	Mouth - Swamp Creek...................						
	0.1 mile up Swamp Creek...............		155.2				
12.6	Dam...................................					u141.9 d140.9	u137.3 d134.2
12.4	Schwenksville Road....................	144.8	147.8	143.3		139.3	
12.1	Schwenksville, Main and Centennial Streets		147.1				
12.0	Sewage Disposal Plant.................		146.9			135.4	
11.55	Haldeman Road.........................			137.2		132.2	
11.30	Mouth - East Branch...................					131.2	

Table 2.--Flood-crest elevations on Perkiomen Creek--Continued

Miles above mouth	Location	Elevation above mean sea level, in feet					
		Aug. 23, 1933	July 9, 1935	Aug. 9, 1942	June 2, 1946	Mar. 7, 1967	Low water Apr. 24, May 2, 1967
10.78	Dam................................					130.6	u121.1 d117.8
10.75	Otis Road..........................	135.3	137.2			130.6	117.8
9.9	U.S.G.S. Gaging Station.............	129.3	130.9	128.2	128.9	124.5	114.2
9.5	Graterford Bridge....................					122.0	
9.24	Reading Railway Bridge...............					120.5	
8.55	Rahns Bridge.........................					115.6	105.4
7.1	Dam and Mill.........................		119.8			u112.5 d111.9	u104.8 d100.7
6.8	House - Mr. Hoover...................	117.7	119.3				
6.64	Perkiomen Bridge.....................	117.7	118.9		116.4	107.9	
5.1	Yerkes Bridge........................		u114.1 d113.7			102.1	91.3
3.6	Arcola Bridge........................		106.1			95.9	
3.55	House - Mrs. John Dyson..............	102.2	104.2			94.5	83.1

Table 2.--Flood-crest elevations on Perkiomen Creek--Continued

Miles above mouth	Location	Elevation above mean sea level, in feet					
		Aug. 23, 1933	July 9, 1935	Aug. 9, 1942	June 2, 1946	Mar. 7, 1967	Low water Apr. 24, May 2, 1967
2.55	Dam (Indian Head)......................		102.1			u90.4 d88.6	u83.0 d78.0
1.8	House (on Perkiomen Road).............		95.0			87.9	
1.7	Egypt Road............................		94.5			86.2	75.4
.9	Dam...................................					83.8	u74.5 d71.7
.41	Pump house of B. F. Goodrich Co.......		89.1				
.4	Penn Central Railroad Bridge..........					81.9	
.25	Dam...................................						u69.3 d65.4
.20	Montgomery County Sewage Disposal Plant................................					u81.7 d81.4	
0	Confluence with Schuylkill River......	89.5				81.4	65.2

u Upstream
d Downstream

Table 3.--Mean sea level reference points

Map designation	Reference mark description	Elevation above mean sea level, in feet
242	USC&GS B.M., at Green Lane, Pa.; 31 feet west of the center line of State Highway No. 29; south of the Reading Company Railway Track; standard disk, stamped, "Y 182 1942" set in the top of the northeast corner of a signal battery concrete housing...............	242.096
148	USGS B.M., 70 feet north of northwest corner of Schwenksville Railway Station; 80 feet west of west rail of main track of Reading Company Railway; 30 feet east of State Highway 29; at southwest corner of hedgerow; in concrete post; standard tablet stamped "17 WSM 148 1947.".....................	148.269
143	USGS B.M., 0.3 mile south of Graterford; 85 feet north of intersection of Reading Company Railway and State Highway No. 29; 60 feet east of east rail; 30 feet east of highway; 10 feet south of gravel driveway; 10 feet west of 24-inch oak tree in concrete post; standard tablet stamped "16 WSM 143 1947."......	143.233
139	USGS B.M., 0.5 mile north of Collegeville along State Highway 29 at abandoned road over railway; one foot east of highway curb; eight feet south of highway curve marker in concrete post; standard USGS brass tablet stamped "15 WSM 139 1947.".................................	138.977
108	USC&GS B.M., 0.25 mile north of Reading Company Railway Station at Perkiomen Junction; 8 feet east of rail standard disk set in concrete post stamped "107.857 S 1 1929."...........	107.857